ADVERTISING WITHIN THE BRANDING PROCESS OF THE CROATIAN WOOD INDUSTRY

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Abstract

Along with the entire economy, the wood industry in the Republic of Croatia also has to face strong and numerous competitors, both in the home and foreign markets. Solutions for survival and future development should be sought in market competition. Modern marketing increasingly uses branding as the means to increase sales and profit. Advertising as a part of the branding process is an unavoidable step toward creating a strong brand.

To optimise the decision making process when selecting an appropriate media combination for advertising, in the paper linear programming is used, particularly a special case of linear programming – integer linear programming. One possibility is to use the technique for distribution of a fixed or limited budget across various media – radio or TV commercials, newspaper adverts, direct mail, etc. The other possibility is to use advertising space (and type of advertising) based on the greatest possible number of potential users that can be reached by the advertising message.

JEL Classification: M31, M37

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1. Introduction to advertising and elements of programming

Quantitative methods and models can be applied in many fields of marketing decision making. Selection of an optimal strategy for advertising of products/companies is one of the problems that marketing management often faces.

As consumers make purchase decisions under significant influence of the media, advertising issues should be carefully considered.

The term advertising refers to a form of promotion, a creative communication process aligned with interests and needs of consumers, producers and society as a whole (Sudar & Keller; 1991, 60). The key objective of advertising is to reduce the distance between the producer and the consumer, that is, to enable targeting, accelerating and quantitative increase of product transfer from producer to consumer. To consumers it provides better insight into a growing offer of products in the market. Advertising makes it easier for buyers/consumers to make an alternative choice, obtain information on new products or improved quality of products and it also improves selective demand (Meler; 2005, 266-267).

There are many classifications of advertising. One of them is carried out according to the type of the media used. This classification includes the following media (Meler; 2005, 269):

a) Newspapers

b) Weekly magazines, reviews and other publications,

c) Radio,

d) Television,

e) Public address system,

f) New media, etc.

Any information directed at product consumers through the media is called an advertising message. As remembering the advertising message significantly depends on the number of repetitions of the advertising message as well as on the time period between the repetitions, increased number of repetitions of advertising messages along with simultaneous concentration significantly increases the level of effectiveness of the advertising message. Cumulative effect occurring in remembering the advertising message is the fact that should be taken into account when planning an advertising campaign, that is, when choosing the media.

The task of marketing management is to choose the types of advertising that will ensure the best balance between the cost of investment and expected effects.

Linear programming models are used in the field of advertising as an aid in making a decision about choosing an appropriate combination of media for advertising. These techniques can sometimes be used for distribution of a fixed or limited

budget across different media – radio or TV commercials, newspaper adverts, direct mail, etc. The other possibility is using the advertising space (and advertising type) based on the largest possible number of potential users that can be reached with advertising message.

Linear programming methods are the most important instrument in operations research, and one of the disciplines in mathematical optimizing.

Each linear programming method consists of the following:

a) LINEAR GOAL FUNCTION – The goal of optimizing comes to the foreground here. It can be maximizing profits, but also minimizing costs. The goal is chosen depending on the problem structure. The goal function is a set that should meet the requirements of the decision-maker.

b) LINEAR RESTRICTIONS – They come from the environment of the decision-maker and impose certain restrictions / conditions in terms of achieving the goal. The restrictions are always specified in the form of equations or inequations.

c) CONDITIONS FOR VARIABLE NON-NEGATIVITY – for example, negative quantities of products cannot be produced, and it is impossible to broadcast a negative number of advertising messages in a medium.

THE GENERAL MATHEMATICAL FORMULA FOR LINEAR PROGRAMMING IS AS FOLLOWS (Barković; 2002, 58):

$$\max Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$$

$$\begin{aligned}
&a_{11}x_1 + a_{12}x_2 + \ldots + a_{1j}x_j + \ldots + a_{1n}x_n \le b_1\\
&a_{21}x_1 + a_{22}x_2 + \ldots + a_{2j}x_j + \ldots + a_{2n}x_n \le b_2\\
&\quad\vdots \qquad\quad \vdots \qquad\qquad \vdots \qquad\qquad \vdots \qquad \vdots\\
&a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mj}x_j + \ldots + a_{mn}x_n \le b_m
\end{aligned}$$

$$x_1 \ge 0, x_2 \ge 0, x_n \ge 0$$

where :

m – is the number of restrictions,

n – is the volume of particular activities,

x_j – is the unknown activity j (structural variable),

a_{ij} – are technical coefficients which indicate how many units of a resource (restriction) are being spent for producing a unit x_j,

b_i – is the size of the restricting factor,

c_j – is the profit per unit j.

However, in many real problems structural variables make sense only if they acquire some integer values. If requiring integer values is the only way in which a problem deviates from a linear programming formulation, then it is an integer programming (IP) problem.

The mathematical model for integer programming is the linear programming model with the one additional restriction that the variables must have integer values (Hillier & Lieberman; 2001, 576). If it is required that only some of the variables have integer values, then such problem is called Mixed Integer Programming. In addition to problems with integer variables, linear programming can be also used to solve problems where decisions of Yes/No type are required. Such variables can acquire only two values (0 or 1). They are called binary (dummy) variables, and problems consisting of binary variables only are called Binary programming problems.

Most methods of integer programming involve the simplex method, applying it to a linear programme that corresponds to the set integer programme, i.e. the problem where requests that variables are integer/binary are omitted. Such a linear programme (that corresponds to the initial integer programme, but without integer variables) is called a linear programming relaxation.

Therefore integer linear programming involves well-researched optimisation problems, and numerous techniques for finding an optimal solution have been developed. Two of these techniques include *a cutting plane method* (Gomory; 1960) and *a branch and bound method* (Land & Doig; 1960). *Cutting plane methods* rely on the algorithm derived by Gomory where the number of possible solutions is iteratively reduced by introducing hyperplanes with the goal to achieve the optimal solution – an integer – in an increasingly narrowing group. *Branch and bound method* consists of consecutive solving of a relaxation problem where new constraints are added in each step and these constraints force individual integer variables to acquire integer values.

A single integer programming problem requires finding a solution to a whole range of linear programming problems, which makes integer programming complex in more than one way.

For more details refer to the authors: Nemhauser and Wolsey (1988), Hillier and Lieberman (2001), Winston and Venkataramanan (2003).

Application of integer programming (IP) on the problems in the field of marketing decision making will be shown in this paper. Solutions will be calculated by means of the POM – QM software for Windows.

2. EXAMPLE OF FORMULATING AND SOLVING A MARKETING DECISION MAKING MODEL

To present the proposed model to a greater number of decision makers in the field of marketing management, the procedure of its formation and solution will be presented on the example from the Croatian wood industry in which company management is going to implement a comprehensive advertising campaign within a one-month period.

It is assumed that the marketing department within the Croatian wood industry company is considering several possibilities of advertising:

- A 10-second TV commercial on NOVA TV in the prime time (period from 19:30 to 23:30)
- Advertisement in daily newspaper, Jutarnji list in this example; a full page colour advert in Saturday edition
- A 20-second radio commercial aired on Narodni radio in the period from 06:00 to 21:00
- Internet advertising on the sites Net.hr, Indeks.hr, Jutarnji.hr, Večernji.hr and contextual media – Google and Facebook

The objective of the Croatian wood industry company is to reach the greatest possible number of potential consumers of its products through various types of advertising.

A research was conducted to obtain information about the number of potential consumers of company's products that would be reached by the advertising message through advertising in a particular type of the media and to obtain information

about costs per one advertising message. The average values of the required data calculated on the basis of data gathered in the above research are given in Table 1.

Table 1: Number of potential consumers and unit price of the message in particular media

MEDIA	Number of potential consumers	Price of the message (HRK)
TV commercial (10 seconds) - NOVA TV in the period 19:30 - 23:30	128,210	4,016.430
Daily newspaper (1 page) - Jutarnji list, Saturday, 1/1 colour	245,304	20,799.890
Radio commercial (20 seconds) - Narodni radio in the period 6:00 - 21:00	32,003	406.280
Internet advertising	0.680	0.013

As can be seen from the table above, advertising in daily newspaper has the highest price per unit (HRK 20,799.89) and one message can reach maximum 245,304 potential consumers – also through advertising in daily newspaper.

However, if the number of potential consumers and the unit price of the message are put into a relation, it is possible to obtain data on the number of potential consumers per kuna invested into a particular form of advertising. This information shows that there are only 11.79 potential consumers per kuna invested into advertising in daily newspaper, whereas advertising on the radio results in 78.77 potential consumers per invested kuna.

Table 2: Number of potential consumers per kuna invested into a particular form of advertising

MEDIA	Number of potential consumers
TV commercial (10 seconds) - NOVA TV in the period 19:30 - 23:30	31.92
Daily newspaper (1 page) - Jutarnji list, Saturday, 1/1 colour	11.79
Radio commercial (20 seconds) - Narodni radio in the period 6:00 - 21:00	78.77
Internet advertising	52.31

The amount of budget allocated by the Croatian wood industry company for that purpose – 200,000.00 kuna, and the requirements of the company regarding the maximum number of advertising messages that the company wishes to order within a month are taken as a constraint to the observed problem:

Table 3: Requirements of the wood industry company regarding the maximum number of advertising messages that the company wishes to order within a month

MEDIA	Maximum number of adverts (per month)
TV commercial (10 seconds) - NOVA TV in the period 19:30 – 23:30	30
Daily newspaper (1 page) - Jutarnji list, Saturday, 1/1 colour	4
Radio commercial (20 seconds) - Narodni radio in the period 6:00 - 21:00	84
Internet advertising	3,500,000

Based on the data from the Tables 1 and 3 it is possible to formulate the problem mathematically as follows:

Assuming:

x_1 - The number of 10-second TV commercials per month
x_2 - The number of full page adverts in daily newspaper per month
x_3 - The number of 20-second radio commercials per month
x_4 - The number of advertising messages on the Internet per month

The function of the objective that should be maximised is the coverage with listeners, readers, viewers, and that is

$$\max Z = 128{,}210x_1 + 245{,}304x_2 + 32{,}003x_3 + 0.68x_4$$

with constraints

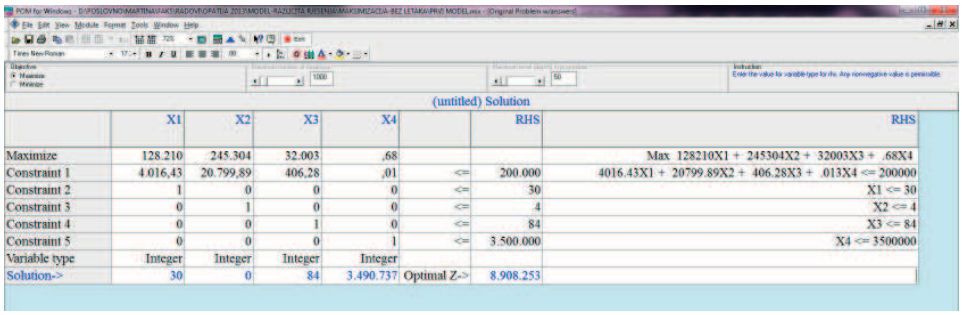
$$4{,}016.43x_1 + 20{,}799.89x_2 + 406.28x_3 + 0.013x_4 \leq 200{,}000.00$$
$$x_1 \leq 30$$
$$x_2 \leq 4$$
$$x_3 \leq 84$$
$$x_4 \leq 3{,}500{,}000$$

and non-negativity condition:

$$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0$$

Input data along with corresponding output data in the software POM – QM for Windows are given in the Figure 1.

Figure 1: Input data of the mathematical problem, together with the corresponding output data in POM – QM for Windows



(untitled) Solution

	X1	X2	X3	X4		RHS	RHS
Maximize	128.210	245.304	32.003	,68			Max 128210X1 + 245304X2 + 32003X3 + .68X4
Constraint 1	4.016,43	20.799,89	406,28	,01	<=	200.000	4016.43X1 + 20799.89X2 + 406.28X3 + .013X4 <= 200000
Constraint 2	1	0	0	0	<=	30	X1 <= 30
Constraint 3	0	1	0	0	<=	4	X2 <= 4
Constraint 4	0	0	1	0	<=	84	X3 <= 84
Constraint 5	0	0	0	1	<=	3.500.000	X4 <= 3500000
Variable type	Integer	Integer	Integer	Integer			
Solution->	30	0	84	3.490.737	Optimal Z->	8.908.253	

The obtained solution is consistent with Table 2. The planned budget is allocated among the media with better ratio between the invested amount and the number of potential consumers.

TV and radio advertising has reached the limit of the company's requirement in terms of the maximum number of advertising messages that the company wishes to order within a month; 3,490,737 advertising messages will be published on the Internet, whereas no advertising messages will be published in daily newspaper.

Therefore the optimum solution is:

$$x_1^* = 30, x_2^* = 0, x_3^* = 84, x_4^* = 3{,}490{,}737$$

at maximum coverage level (the number of people noticing the given advertising message) of 8,908,253.

However, if the Croatian wood industry company would also require the following:

- 4 adverts to be published in daily newspapers within the observed period

- At least 40 commercials to be aired on the radio within the observed period
- At least HRK 10,000.00 to be invested into advertising messages on the Internet, but not exceeding HRK 20,000.00
- The cost of adverts in daily newspapers and advertising on the radio not to exceed HRK 100,000.00

the problem would be mathematically formulated as follows:

$$\max Z = 128{,}210x_1 + 245{,}304x_2 + 32{,}003x_3 + 0.68x_4$$

with constraints

$$4{,}016.43x_1 + 20{,}799.89x_2 + 406.28x_3 + 0.013x_4 \leq 200{,}000.00$$
$$x_1 \leq 30$$
$$x_2 = 4$$
$$x_3 \leq 84$$
$$x_3 \geq 40$$
$$x_4 \leq 3{,}500{,}000$$
$$0.013x_4 \leq 20{,}000$$
$$0.013x_4 \geq 10{,}000$$
$$406.28x_3 + 0.013x_4 \leq 50{,}000$$
$$20{,}799.89x_2 + 406.28x_3 \leq 100{,}000$$

and non-negativity condition:

$$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0$$

Optimum solution of the observed problem would be (also calculated by means of the POM – QM software for Windows):

$x_1^* = 20$ (number of TV commercials),

$x_2^* = 4$ (number of newspaper adverts),

$x_3^* = 41$ (number of radio commercials),

$x_4^* = 1{,}524{,}181$ (number of advertising messages on the Internet),

at maximum coverage level (people noticing the given advertising message) of 5,893,983.

The other possibility for using the integer programming model in the field of advertising is to use it as an aid when making a decision about appropriate combination of the media for advertising in order to achieve the desired coverage level, while maintaining the costs of advertising at the lowest possible level.

For example, if the Croatian wood industry company's management would be satisfied with the coverage level of 3,000,000 of potential consumers, then the number of advertising messages for a particular medium should be determined so that minimal advertising costs are achieved.

With the above information about the number of potential consumers, unit prices of messages and constraints, the new problem can be mathematically formulated as follows:

$$\min Z = 4{,}016.43x_1 + 20{,}799.89x_2 + 406.28x_3 + 0.013x_4$$

with constraints

$$4{,}016.43x_1 + 20{,}799.89x_2 + 406.28x_3 + 0.013x_4 \leq 200{,}000.00$$
$$x_1 \leq 30$$
$$x_2 = 4$$
$$x_3 \leq 84$$
$$x_3 \geq 40$$
$$x_4 \leq 3{,}500{,}000$$
$$0.013x_4 \leq 20{,}000$$
$$0.013x_4 \geq 10{,}000$$
$$406.28x_3 + 0.013x_4 \leq 50{,}000$$
$$20{,}799.89x_2 + 406.28x_3 \leq 100{,}000$$
$$128{,}210x_1 + 245{,}304x_2 + 32{,}003x_3 + 0.68x_4 \geq 3{,}000{,}000$$

and non-negativity condition:

$$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0$$

The optimal solution to this problem would be calculated by means of the POM – QM software for Windows:

$x_1^* = 0$ (number of TV commercials),

$x_2^* = 4$ (number of newspaper adverts),

$x_3^* = 41$ (number of radio commercials),

$x_4^* = 1{,}039{,}207$ (number of advertising messages on the Internet).

at minimal costs in amount of HRK 113,366.70.

However, if there is an additional requirement by the Croatian wood industry company's management in terms of the number of commercials – at least 15 TV commercials to be broadcasted within a month, then the problem will be mathematically formulated as in the Figure 2, and optimal solution will be:

$x_1^* = 15$ (number of TV commercials),

$x_2^* = 4$ (number of newspaper adverts),

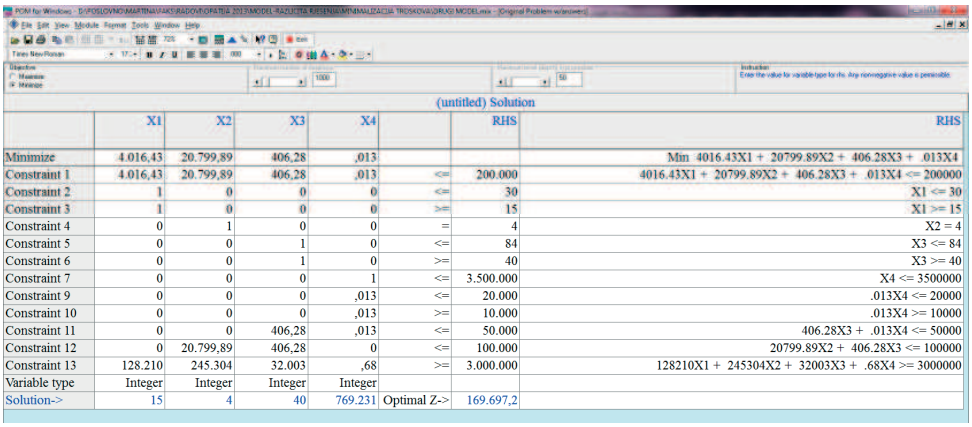
$x_3^* = 40$ (number of radio commercials),

$x_4^* = 769{,}231$ (number of advertising messages on the Internet).

ımal costs in the amount of HRK 169,697.20 kn.

at minimal costs in the amount of HRK 169,697.20 kn.

Figure 2: Input data of the mathematical problem, together with the corresponding output data in POM – QM for Windows



(untitled) Solution

	X1	X2	X3	X4		RHS	RHS
Minimize	4.016,43	20.799,89	406,28	,013			Min 4016.43X1 + 20799.89X2 + 406.28X3 + .013X4
Constraint 1	4.016,43	20.799,89	406,28	,013	<=	200.000	4016.43X1 + 20799.89X2 + 406.28X3 + .013X4 <= 200000
Constraint 2	1	0	0	0	<=	30	X1 <= 30
Constraint 3	1	0	0	0	>=	15	X1 >= 15
Constraint 4	0	1	0	0	=	4	X2 = 4
Constraint 5	0	0	1	0	<=	84	X3 <= 84
Constraint 6	0	0	1	0	>=	40	X3 >= 40
Constraint 7	0	0	0	1	<=	3.500.000	X4 <= 3500000
Constraint 9	0	0	0	,013	<=	20.000	.013X4 <= 20000
Constraint 10	0	0	0	,013	>=	10.000	.013X4 >= 10000
Constraint 11	0	0	406,28	,013	<=	50.000	406.28X3 + .013X4 <= 50000
Constraint 12	0	20.799,89	406,28	0	<=	100.000	20799.89X2 + 406.28X3 <= 100000
Constraint 13	128.210	245.304	32.003	,68	>=	3.000.000	128210X1 + 245304X2 + 32003X3 + .68X4 >= 3000000
Variable type	Integer	Integer	Integer	Integer			
Solution->	15	4	40	769.231	Optimal Z->	169.697,2	

3. CONCLUSION

The paper provides a presentation of a support system to marketing decision making, both theoretically and on an example from the Croatian wood industry.

The support system is based on linear programming models, particularly on a special case of linear programming – integer linear programming.

Marketing management of the company from the Croatian wood industry can use the system to choose the types of advertising that will provide the best balance between investment costs and expected effects, thus determining the optimal advertising strategy in given circumstances.

Information technology is of key importance for the proposed model. Its importance is particularly visible in the field of model solution. That aspect of computers and software implementation is pointed out in the analysis. As most marketing managers have only basic knowledge and skills in the field of information technologies and quantitative methods, this approach was used to present the support system to decision making to a greater number of users. Therefore the software used in the analysis is the software known for its availability and ease of use.

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